

(19) 日本国特許庁 (J P)

(12) 公開特許公報 (A)

(11) 特許出願公開番号

特開2001-75032

(P2001-75032A)

(43) 公開日 平成13年3月23日 (2001.3.23)

(51) Int.Cl.⁷
G 0 2 B 26/10

識別記号

F I
G 0 2 B 26/10

テーマコード(参考)

A 2 H 0 4 5
D

審査請求 未請求 請求項の数 6 O L (全 9 頁)

(21) 出願番号 特願平11-247540

(22) 出願日 平成11年9月1日 (1999.9.1)

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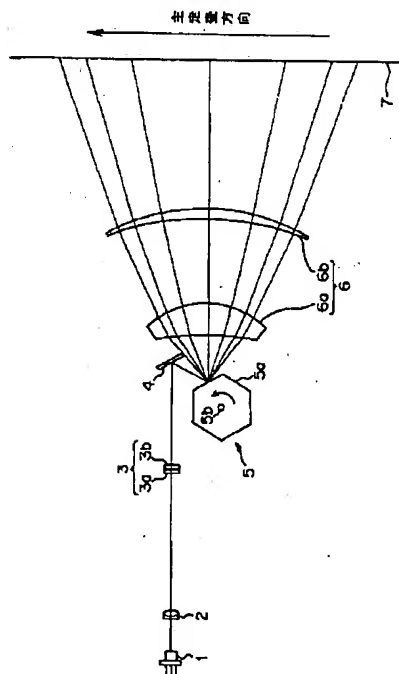
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(54) 【発明の名称】 光走査装置

(57) 【要約】

【課題】 環境温度の変化に伴う主・副走査方向の焦点位置ずれを光学系の全系で自己補正し、温度変化に拘わらず被走査面上に小径の光スポットを形成することができる光走査装置を実現する。

【解決手段】 光源1と、光源からの光束を以後の光学系にカップリングする光学系2と、該カップリング光学系からの光束を偏向反射面5aで反射して偏向する光偏向器5と、光偏向器による偏向光束を被走査面7上に光スポットとして集光する走査結像光学系6と、環境変動などに伴う被走査面上の光スポットの焦点位置ずれを自己補正するための補正光学系3を備えた光走査装置において、補正光学系3は、主走査、副走査方向共に負のパワーを持つアナモフィック面を有する樹脂製レンズ3aと、少なくとも副走査方向に正のパワーを持つアナモフィック面を有するガラスレンズ3bとを少なくとも1対有し、カップリング光学系2と偏向反射面5aの間に設置される構成とした。



【特許請求の範囲】

【請求項1】 光束を放射する光源と、該光源からの光束を平行光束もしくは略収束光束あるいは略発散光束に変換して以後の光学系にカップリングするカップリング光学系と、該カップリング光学系からの光束を偏向反射面で反射して偏向走査する光偏向器と、該光偏向器による偏向光束を被走査面上に光スポットとして集光する走査結像光学系と、環境変動などに伴う上記被走査面上の光スポットの焦点位置ずれを自己補正するための補正光学系を備えた光走査装置において、

上記補正光学系は、主走査方向、副走査方向共に負のパワーを持つアナモフィック面を有する樹脂製レンズと、少なくとも副走査方向に正のパワーを持つアナモフィック面を有するガラスレンズとを少なくとも1対有し、上記カップリング光学系と上記偏向反射面の間に設置されることを特徴とする光走査装置。

【請求項2】 請求項1記載の光走査装置において、アナモフィック面を有する樹脂製レンズとアナモフィック面を有するガラスレンズからなる補正光学系を保持部材で一体に保持したことを特徴とする光走査装置。

【請求項3】 請求項2記載の光走査装置において、保持部材で一体化した補正光学系が光軸方向に移動調整可能な構造を有することを特徴とする光走査装置。

【請求項4】 請求項2記載の光走査装置において、保持部材で一体化した補正光学系が光軸に垂直な方向に回転調整可能な構造を有することを特徴とする光走査装置。

【請求項5】 請求項1、2、3または4記載の光走査装置において、補正光学系のアナモフィック面の少なくとも1面が主・副走査方向共に非球面で構成されることを特徴とする光走査装置。

【請求項6】 請求項1、2、3、4または5記載の光走査装置において、アナモフィック面を有する樹脂製レンズとアナモフィック面を有するガラスレンズの間隔を L とし、補正光学系全系の副走査方向の焦点距離を f_s としたとき、条件：

$$0 < L / f_s < 0.1$$

を満足することを特徴とする光走査装置。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】 本発明は、レーザープリンタ、デジタル複写機、ファクシミリ等の画像形成装置の書込光学系や、計測器、検査装置等に応用される光走査装置に関する。

【0002】

【従来の技術】 光源からの光束を光偏向器で偏向し、走査光学系で被走査面上に光スポットとして集光して、被走査面上を走査する光走査装置は、従来からレーザープリンタやデジタル複写機、ファクシミリ等に関連して広く知られている。このような光走査装置において、レンズコストを低減させる目的や、特殊なレンズ面形状を具

現する目的で、樹脂製レンズの使用が意図されている。殊に偏向光束を被走査面上に結像させる走査結像光学系を構成するレンズ（走査結像レンズ）は、像面湾曲やリニアリティ等の等速特性の良好な補正を目的として特殊なレンズ面形状が種々提案されているが、このような特殊なレンズ面形状を実現するためには樹脂製レンズが適している。一方、周知の如く樹脂製レンズには、温度変化に伴う体積変化により、レンズ面の曲率や屈折率が変化し、レンズ性能、特に被走査面上での光スポットの焦点位置が変化するという問題がある。この焦点位置の変化は、被走査面上における光スポットのスポット径を増大させてビーム太りを生じ、光走査の解像度を低下させる原因となる。

【0003】 そこで、樹脂製レンズの温度変化に伴う焦点位置の変化は、正レンズと負レンズとで互いに逆に発生するので、上記焦点位置の変化を補正するために、光源から光偏向器に至る光路上に、樹脂製の走査結像レンズと逆のパワーを持つ樹脂製レンズを配備して、走査結像レンズの温度変化による焦点位置の変化を相殺することが知られている（特開平8-160330号公報、特開平8-292388号公報）。ここで、特開平8-160330号公報記載の光走査装置は、光源、入射光学系、偏向器、走査光学系、被走査媒体を含む構成であり、入射光学系は、光源からの発散光束を平行光束にする第一の光学系（コリメートレンズ）と、該第一の光学系を介した光源からの光を副走査方向において偏向器近傍で結像させる第二の光学系とからなり、第一の光学系、あるいは第二の光学系のいずれかに副走査方向に負のパワーを持つ樹脂製の光学素子（レンズ）を含む構成としている。また、特開平8-292388号公報記載の走査光学装置は、偏向器の偏向位置近傍で結像させる第1結像部において、副走査方向にのみ負の屈折力を有し、樹脂を材料とする負レンズを備え、温度補償を行う構成としている。

【0004】

【発明が解決しようとする課題】 しかしながら、上記従来技術に記載された光走査装置では、光源と光偏向器との間に配備される補正用の樹脂製レンズは、副走査方向にのみ負のパワーを持つレンズであり、主走査方向に関してはパワーを持たないので、走査結像レンズの温度変化に伴う主走査方向の焦点位置ずれ（光スポットの結像位置のずれ）は補正できなかった。また、従来技術における補正用レンズは、レンズ断面を通常の円弧形状で構成していたため、補正用レンズによって、かえって波面収差を劣化させ光スポットの小径化の妨げとなるという問題があった。

【0005】 本発明は上記事情に鑑みなされたものであって、偏向光束を被走査面上に結像させる光学系に樹脂製レンズを用いた場合にも、環境温度の変化に伴う主走査方向及び副走査方向の焦点位置ずれを光学系の全系で

自己補正し、温度変化に拘わらず被走査面上に小径の光スポットを形成することができる光走査装置を実現することを課題とする。

【0006】

【課題を解決するための手段】上記課題を解決するための手段として、本発明に係る光走査装置は、光束を放射する光源と、該光源からの光束を平行光束もしくは略収束光束あるいは略発散光束に変換して以後の光学系にカップリングするカップリング光学系と、該カップリング光学系からの光束を偏向反射面で反射して偏向走査する光偏向器と、該光偏向器による偏向光束を被走査面上に光スポットとして集光する走査結像光学系と、環境変動などに伴う上記被走査面上の光スポットの焦点位置ずれを自己補正するための補正光学系を備えている。そして上記補正光学系は、主走査方向、副走査方向共に負のパワーを持つアナモフィック面を有する樹脂製レンズと、少なくとも副走査方向に正のパワーを持つアナモフィック面を有するガラスレンズとを少なくとも1対有し、上記カップリング光学系と上記偏向反射面の間に設置されている（請求項1）。

【0007】上記請求項1に係る光走査装置において、アナモフィック面を有する樹脂製レンズとアナモフィック面を有するガラスレンズからなる補正光学系は保持部材で一体に保持することが好ましい（請求項2）。そして上記請求項2に係る光走査装置において、保持部材で一体化した補正光学系は、光軸方向に移動調整可能な構造を有することが好ましい（請求項3）。あるいは上記請求項2に係る光走査装置において、保持部材で一体化した補正光学系は、光軸に垂直な方向に回転調整可能な構造を有することが好ましい（請求項4）。さらに、上記請求項1、2、3または4に係る光走査装置において、補正光学系のアナモフィック面の少なくとも1面は、主・副走査方向共に非球面で構成されることが好ましい（請求項5）。また、上記請求項1、2、3、4または5に係る光走査装置において、アナモフィック面を有する樹脂製レンズとアナモフィック面を有するガラスレンズの面間隔を L とし、補正光学系全系の副走査方向の焦点距離を f_s としたとき、条件： $0 < L/f_s < 0.1$ を満足することが好ましい（請求項6）。

【0008】

【発明の実施の形態】以下、本発明の構成、動作及び作用を図面を参照して詳細に説明する。図1は本発明の一実施形態を示す図であって、光走査装置を構成する光学系の配置を主走査平面（光軸と主走査方向に平行な平面）に展開して示した光学配置説明図である。図1に示す光学系は、光束を放射する光源1と、この光源1からの光束を平行光束もしくは略収束光束あるいは略発散光束に変換して以後の光学系にカップリングするカップリング光学系2と、カップリング光学系2からの光束を偏向反射面5aで反射して偏向走査する光偏向器5と、光

偏向器5による偏向光束を被走査面7上に光スポットとして集光する走査結像光学系6と、環境変動などに伴う上記被走査面上の光スポットの焦点位置ずれを自己補正するための補正光学系3を備えている。そして補正光学系3は、主走査方向、副走査方向共に負のパワーを持つアナモフィック面を有する樹脂製補正レンズ3aと、少なくとも副走査方向に正のパワーを持つアナモフィック面を有するガラス製補正レンズ3bとを少なくとも1対有し、上記カップリング光学系2と上記偏向反射面5aの間に設置されている（請求項1）。尚、符号4は光路折り曲げ用の平面鏡であり、必要に応じて設置される。

【0009】ここで、光源1としては半導体レーザが用いられるが、発光ダイオード（LED）等を利用することもできる。カップリング光学系2は単数あるいは複数のレンズで構成されるカップリングレンズであり、光源1から放射される発散性の光束を平行光束もしくは略収束光束あるいは略発散光束に変換して以後の光学系（補正光学系）に適合させるようにカップリングする。このカップリングレンズ2はガラスレンズでも樹脂製レンズでもよいが、温度等の環境変化に影響されにくいガラスレンズで構成することが好ましい。また、球面収差を除去するためにレンズ面を非球面形状としてもよい。補正光学系3は主走査及び副走査の両方向に対して、環境変動（温度、湿度）に伴う焦点位置ずれを補正するものであるが（詳細は後述する）、通常は線像結像光学系としての機能を有し、図2の（a）主走査方向の平面に展開した光路図及び（b）副走査方向の平面に展開した光路図に示すように、カップリングレンズ2からの光束を副走査方向（図1では紙面に直交する方向）に収束して、光偏向器5の偏向反射面5a近傍に主走査方向に長い線像として結像する。光偏向器5はモータの回転軸5bを中心軸として等速回転する回転多面鏡（ポリゴンミラー）であり、偏向反射面5aによる反射光束を、ポリゴンミラー5の等速回転により等角速度的に偏向する。尚、光偏向器としては、ポリゴンミラーの他に、回転単面鏡や回転2面鏡等を好適に利用できる。走査結像光学系6は、図1の例では2枚の走査レンズ6a、6bにより構成され、走査レンズ6a、6bの作用によりポリゴンミラー5からの偏向光束を被走査面7（レーザープリンタやデジタル複写機等の画像形成装置では、光導電性の感光体の感光面等が被走査面となる）上に微小な光スポットとして集光する。尚、走査結像光学系6は、2枚のレンズの組合せに限らず、1枚のレンズで構成したり、3枚以上のレンズで構成することもできる。また、1枚以上のレンズと、結像作用を持つ凹面鏡や $f\theta$ ミラー等との組合せで構成することもできる。さらに、図1のように走査結像光学系6を2枚の走査レンズ6a、6bで構成する場合、主・副走査方向の像面湾曲の補正や、等速特性（リニアリティ、 $f\theta$ 特性）の改善のために、少なくとも一方の走査レンズにはレンズ面が非球面形状の樹

脂製レンズが用いられる。

【0010】次に本発明の特徴である補正光学系3について説明する。図1、2に示すように、補正光学系3は、主走査方向、副走査方向で共に負のパワーを持つアナモフィック面を有する樹脂製の補正レンズ3aと、少なくとも副走査方向に正のパワーを持つアナモフィック面（シリンダ面を含む）を有するガラス製の補正レンズ3bから構成されており、環境温度の変動に伴う被走査面7上の主走査方向の結像位置ずれ及び副走査方向の結像位置ずれを良好に補正すべく、該アナモフィック面の曲率、線膨張係数、屈折率の温度依存性が最適に定められている。

【0011】ここで、補正光学系3の補正レンズ3a、3bをアナモフィック面とすることにより次の効果が得られる。

①主走査及び副走査の両方向に対して、環境（温度、湿度）の変動に伴う焦点位置ずれを補正することができる。

②アナモフィック面を用いることにより、対向面は平面とすることができるため、これを取り付け基準面とすることができ、光学性能を劣化させる偏心の発生が抑えられる。

③近年の切削、研磨加工技術の発展により、アナモフィック面は比較的容易に加工できるようになってきた。従って、これまでのようにシリンダ面、球面等を組み合わせること無く実現できる。

【0012】また、本発明は環境（温度、湿度）の変動に伴う走査結像光学系6（走査レンズ6a、6b）の焦点位置ずれをポリゴンミラー5の偏向反射面5a以前の補正光学系3で自己補正するものであり、像面湾曲自体は基本的には補正しない。従って走査結像光学系6の像面湾曲（1走査内での焦点ずれの偏差）は予め良好に補正しておくことが望ましい。そこで、後述する実施例では、走査結像光学系6を構成する走査レンズ6a、6bの面形状をアナモフィック面（例えば、トロイダル面や特殊トロイダル面）として、図4に示すように像面湾曲や等速特性（リニアリティ、 $f\theta$ 特性）などの光学性能を改善している。尚、上記の特殊トロイダル面とは、副走査断面（主走査方向に直交する仮想的な断面）内の曲率が、主走査方向において変化するトロイダル面である。

【0013】次に、図1、2に示す構成の光走査装置において、アナモフィック面を有する樹脂製補正レンズ3aとアナモフィック面を有するガラス製補正レンズ3bからなる補正光学系3は保持部材で一体に保持することが好ましく、例えば図3に示すように、補正光学系3の樹脂製補正レンズ3aとガラス製補正レンズ3bを補正光学系ユニット3cで一体に保持するように構成する。また、補正光学系ユニット3cの外形を円筒状に構成して、V字形の溝を有する台座3dに設置することによ

り、上記溝に沿って光軸Oの方向に移動調節したり、光軸方向に垂直な方向に回転可能な構成とすることができる。

【0014】ここで、補正光学系3を構成する補正レンズ3a、3bを図3に示すようにユニット3cで一体に構成することにより、次のようなメリットがある。

①アナモフィック面が複数存在する場合（後述する実施例では補正光学系の中に2面、走査光学系に4面）、光軸に直交する面内の回転偏心は大きな波面収差を発生し、光スポットの太りを発生する。そこで、補正光学系3の樹脂製補正レンズ3aとガラス製補正レンズ3bを光学系ユニット3cで一体に保持することにより、補正光学系3内で発生する波面収差を組み付け調整時に予め抑えることができる（請求項2）。

②一体化された補正光学系を図3のように光軸方向に移動調整可能な構成とすることにより、補正光学系3を光学系ユニット3c内に組付けるときに、主・副走査方向の焦点位置ずれを予め調整することができる（請求項3）。

④一体化された補正光学系を図3のように光軸方向に垂直な方向に回転可能な構成にすることにより、補正光学系内の波面収差を保ちつつ、光学系全系の調整が可能となる（請求項4）。

【0015】ところで、近年、レーザープリンタやデジタル複写機等の画像形成装置においては書き込みの高密度化が進み、1200dpi（ドット/インチ）を超える高密度書き込みが実現化されつつある。このような高密度化に対応するためには被走査面上の光スポットのスポット径を小径化する必要があり、そのためには光学系の高NA化が必要である。高NA化により光学系を透過する光束が大きくなるため、その際に発生する波面収差が光スポット径に大きく影響を与え、波面収差が大きすぎる場合は小径の光スポットに絞込むことができない。そこで本発明では、補正光学系3を構成する2枚の補正レンズのアナモフィック面の少なくとも1面は、主・副走査方向共に非球面で構成されるようにしている。より具体的には、補正光学系3を構成する補正レンズ3a、3bが、主走査方向または副走査方向に非円弧を有する特殊トロイダル面を少なくとも1面有するようにすることにより、波面収差を良好に補正することが可能となる（請求項5）。補正光学系の具体的な実施例は後述するが、実施例においては、補正光学系の樹脂製レンズ3aの光入射側（カップリングレンズ側）の凹のアナモフィック面を特殊トロイダル面とすることにより波面収差を良好に補正している。尚、図5は、補正光学系3の樹脂製補正レンズ3aの光入射側の凹のアナモフィック面に（a）通常の円弧のトロイダル面を用いた場合と、（b）特殊トロイダル面を用いた場合の波面収差を示しており、特殊トロイダル面とすることにより波面収差が良好に補正されることが判る。

【0016】ここで、上記補正光学系3の補正レンズ3a、3bや、走査結像光学系6の走査レンズ6a、6bに適用される特殊トロイダル面のレンズ面形状を特定するための表現式を説明しておく。ただし、本発明はこの表現式に限定されるものではない。レンズ面を表現するにあたり、レンズ面近傍における主走査方向の座標をY、副走査方向の座標をZとし、これらの原点を光軸に取る。レンズ面の一般式を、

$$f(Y, Z) = f_m(Y) + f_s(Y, Z)$$

とする。ここで、特殊トロイダル面の主走査断面（レンズ光軸を含み、主走査方向に平行な仮想的な断面）内に*

$$X = f(Y, Z) = f_m(Y) + f_s(Y, Z)$$

$$f_m(Y) = (Y^2/R_m) / \{1 + \sqrt{1 - (1 + K_m)(Y/R_m)^2}\}$$

$$+ A_{m1} \cdot Y + A_{m2} \cdot Y^2 + A_{m3} \cdot Y^3 + A_{m4} \cdot Y^4 + A_{m5} \cdot Y^5 + \dots \quad (2)$$

(2)式で、奇数次の係数：A_{m1}, A_{m3}, A_{m5}, …の何れかが0でないとき、非円弧形状は主走査方向に非対称形状となる。また、偶数次の係数：A_{m2}, A_{m4}, A_{m6}, …

のみの場合は主走査方向に対称となる。尚、上記の表記※

$$f_s(Y, Z) = (Z^2 \cdot C_s) / \{1 + \sqrt{1 - (1 + K_s)(Z \cdot C_s)^2}\}$$

$$+ (F_0 + F_1 \cdot Y + F_2 \cdot Y^2 + F_3 \cdot Y^3 + F_4 \cdot Y^4 + \dots) \cdot Z$$

$$+ (G_0 + G_1 \cdot Y + G_2 \cdot Y^2 + G_3 \cdot Y^3 + G_4 \cdot Y^4 + \dots) \cdot Z^2$$

$$+ (H_0 + H_1 \cdot Y + H_2 \cdot Y^2 + H_3 \cdot Y^3 + H_4 \cdot Y^4 + \dots) \cdot Z^3$$

$$+ (I_0 + I_1 \cdot Y + I_2 \cdot Y^2 + I_3 \cdot Y^3 + I_4 \cdot Y^4 + \dots) \cdot Z^4$$

$$+ (J_0 + J_1 \cdot Y + J_2 \cdot Y^2 + J_3 \cdot Y^3 + J_4 \cdot Y^4 + \dots) \cdot Z^5$$

$$+ (K_0 + K_1 \cdot Y + K_2 \cdot Y^2 + K_3 \cdot Y^3 + K_4 \cdot Y^4 + \dots) \cdot Z^6$$

$$+ \dots$$

(3)

ここで、

$$C_s = (1/R_{s0}) + B_1 \cdot Y + B_2 \cdot Y^2 + B_3 \cdot Y^3 + B_4 \cdot Y^4 + B_5 \cdot Y^5 + \dots \quad (4)$$

$$K_s = K_{s0} + C_1 \cdot Y + C_2 \cdot Y^2 + C_3 \cdot Y^3 + C_4 \cdot Y^4 + C_5 \cdot Y^5 + \dots \quad (5)$$

であり、「R_{s0}」は、光軸を含む副走査断面内における近軸曲率半径である。また、Yの奇数次の係数B₁, B₃, B₅, …の何れかが0以外の場合、副走査断面内の曲率が主走査方向に非対称となる。同様に、係数：C₁, C₃, C₅, …, F₁, F₃, F₅, …, G₁, G₃, G₅, …等、非円弧量を表すYの奇数次の係数の何れかが0以外であるとき、副走査の非円弧量が主走査方向に非対称となる。後述の実施例では、補正光学系3の光源側の補正レンズ（樹脂製レンズ）3aの入射面側を上記の式で表記される特殊トロイダル面とし、また、走査結像光学系6の2つの走査レンズ6a、6bの4つのレンズ面を上記の式で表記される特殊トロイダル面としている。

【0018】次に本発明では、図1～3に示す構成の光走査装置において、アナモフィック面を有する樹脂製レンズ3aとアナモフィック面を有するガラスレンズ3bの面間隔をLとし、補正光学系3全系の副走査方向の焦点距離をf_sとしたとき、以下の条件：

$$0.005 < L/f_s < 0.1$$

★

*おける面形状は非円弧形状をなしており、上記の式の右辺第1項のf_m(Y)は主走査断面内の形状を表し、第2項のf_s(Y, Z)は、主走査方向における座標：Yの位置における副走査断面（主走査方向に直交する仮想的な断面）内における形状を表す。

【0017】以下では、上記主走査断面内の形状をf_m(Y)として、周知の非円弧形状の式、即ち、光軸における主走査断面内の近軸曲率半径をR_m、光軸からの主走査方向の距離をY、円錐常数をK_m、高次の係数をA_{m1}, A_{m2}, A_{m3}, A_{m4}, A_{m5}, …とすると、光軸方向のデプスをXとして次の多項式で表している。

(1)

※において、例えば「Y²」は「Y²」を、「Y³」は「Y³」を表す。また、上記f_s(Y, Z)は、以下のように表す。

30★を満足することを特徴としている（請求項6）。ここで、上記条件の上限の0.1を超えると、環境変動による焦点ずれを補正するためには、光偏向器5の偏向反射面5aと補正光学系3の間の距離が長くなりすぎるためレイアウトの制約を受ける。一方、下限の0.005を超えると樹脂製レンズ3aの負のパワーが大きくなりすぎるため、波面収差の劣化を招き、被走査面7上で小径の光スポットを得ることが難しくなる。尚、後述の実施例に示す光学系では、

$$L/f_s = 1.0/131 = 0.0076$$

である。

【0019】さて、以上に説明した構成の本発明に係る光走査装置において、補正光学系3により温度補正を行った場合（温度キャンセル方式）と、温度補正を行わない場合（温度キャンセル無し）の、主・副走査方向の像面変動量（結像位置ずれ）と像面変動幅を比較した結果を下記の表1に示す。

【0020】

【表1】

表 1. 温度補正効果

方式	T	像面変動量 [mm]							像面 変動幅
		h=150	h=122.7	h=76.7	h=0	h=-76.7	h=-122.7	h=-150	
温度キャンセル 無し	主走査	10℃	-1.04	-1.01	-1.07	-1.03	-1.07	-1.01	2.37
		45℃	1.15	1.12	1.18	1.24	1.18	1.12	
	副走査	10℃	-1.24	-1.21	-1.28	-1.24	-1.27	-1.30	2.79
		45℃	1.38	1.35	1.46	1.42	1.45	1.48	
温度キャンセル 方式	主走査	10℃	-0.22	-0.18	-0.14	-0.14	-0.14	-0.16	0.48
		45℃	0.24	0.16	0.14	0.13	0.14	0.16	
	副走査	10℃	-0.18	-0.14	-0.18	-0.11	-0.17	-0.23	0.56
		45℃	0.23	0.33	0.28	0.21	0.28	0.32	

h: 像高、T: 温度

【0021】

【実施例】以下に、図1～3に示した構成の光走査装置における光学系の具体的な実施例を示す。本実施例において、光源1は半導体レーザであり、発光波長: 655 nmである。カップリングレンズ2は、アルミニウム製のセル部材に保持された単玉構成のガラスレンズ (FD 10) であり、焦点距離は $f=22.0$ mm、出射光は平行光束である。尚、本実施例では、カップリングレンズ2の出射側のレンズ面を面番号0として、補正光学系3の樹脂製補正レンズ3aの入射面側を面番号1、出射面側を面番号2とし、ガラス製補正レンズ3bの入射面側を面番号3、出射面側を面番号4とする。また、偏向反射面5aの面番号を5とし、走査結像光学系6を構成する2つの走査レンズ6a、6bは、入射面側から順に面番号を6、7、8、9とする。

【0022】光偏向器5を構成するポリゴンミラーの偏向反射面5aは平面で自然集光点: ∞ であり、このポリゴンミラーは、偏向反射面数: 6面、内接円半径: 25 mmのものであり、回転中心軸5bと反射点 (偏向光束の主光線が、走査レンズ6a、6bの光軸と平行になるときの、上記光線と偏向反射面との交点位置) とは、上記光軸方向に距離: 10.7 mm離れ、主走査方向に距離: 22.69 mm離れている。また、偏向光束の主光*

*線が走査レンズ6a、6bの光軸と平行になる状態において、この主光線と、光源側から偏向反射面に入射する光束の主光線とが成す角度 (即ち、ポリゴンミラーへの入射角) は60度である。また、画角は-38度～+38度である。

【0023】補正光学系3は焦点距離: $f=131$ mmであり、樹脂製の補正レンズ3aは、屈折率: $n=1.52716$ であり、面番号で第1面が凹形状の特殊トロイダル面、第2面が平面である。また、ガラス製の補正レンズ3bは、屈折率: $n=1.514332$ (BK 7) であり、面番号で第3面が凸形状のトロイダル面、第4面が平面である。走査結像光学系6のポリゴンミラー5側の走査レンズ6aは、樹脂製で屈折率: $n=1.52716$ であり、面番号で第6面が凹形状の特殊トロイダル面、第7面が副走査断面の曲率が非対称な凸形状の特殊トロイダル面である。また、被走査面7側の走査レンズ6bは、樹脂製で屈折率: $n=1.52716$ であり、面番号で第8面が副走査断面の曲率が非対称な凹形状の特殊トロイダル面、第9面が主・副走査断面共に非円弧の凸形状の特殊トロイダル面である。ここで、前述の近軸曲率半径: R_m 、 R_{s0} 、光軸上の面間隔: x に対する光学系のレンズデータを以下に示す。

【0024】

	面番号	R_m	R_{s0}	x
補正レンズ3a	1	-100.9	-17.76	3.0
	2	∞	∞	1.0
補正レンズ3b	3	100.0	15.0	3.0
	4	∞	∞	140.64
偏向反射面5a	5	∞	∞	72.560
走査レンズ6a	6	-242.186	242.337	31.572
	7	-83.064	138.908	81.808
走査レンズ6b	8	-239.054	-78.986	9.854
	9	-218.790	-26.516	145.001

【0025】また、上記樹脂製補正レンズ3aの第1面、及び走査レンズ6a、6bの第6面～第9面の特殊トロイダル面のレンズ面形状を特定するための前述の式 (1)～(5) における各係数の値を以下に示す。尚、以下に示す各係数データにおいて、数値の末尾に付けられた※50

※Eとそれに続く数値は10のべき乗を掛けることを表しており、例えば「E-15」は「 $\times 10^{-15}$ 」を意味している。

【0026】

11

第1面:

Am1, Am2, Am3, Am4, Am5, ..=0

B2=-2.9712E-05 , B4=-8.5101E-07 , B6=4.1938E-09
 C0=1.8861E+00 , C1=4.5792E-02 , C3=-5.6507E-04
 I0=-3.0182E-05 , I1=-9.6650E-07 , I3=1.2955E-08
 K0=-1.4683E-06 , K1=4.9604E-08 , K3=1.2755E-08

【0027】

第6面:

Am2=6.9335E-01 , Am4=-3.7002E-09 , Am6=5.3962E-12
 Am8=-2.6877E-14 , Am10=3.2892E-18
 B2=-1.0850E-05 , B4=4.4623E-09 , B6=-1.4980E-12
 B8=-1.1955E-15 , B10=1.4318E-18 , B12=-3.5225E-22
 B14=-2.8072E-25 , B16=1.3039E-28

【0028】

第7面:

Am2=-2.3702E-01 , Am4=5.2751E-08 , Am6=-2.0673E-13
 Am8=6.1916E-16 , Am10=-2.1272E-18
 B1=1.1285E-05 , B3=8.2414E-09 , B5=-8.3701E-12
 B7=1.6093E-15 , B9=1.0336E-19

【0029】

20

第8面:

Am2=-9.0813E+00 , Am4=-1.3697E-10 , Am6=-1.0361E-12
 Am8=-1.5020E-16 , Am10=-1.2669E-21 , Am12=-4.0301E-25
 Am14=5.7340E-30 , Am16=1.6885E-33
 B1=1.5474E-06 , B3=2.8010E-10 , B5=-1.2492E-13
 B7=2.5220E-17 , B9=-3.6112E-21 , B11=2.9135E-25
 B13=-1.6452E-29 , B15=1.7857E-33 , B17=-1.0747E-37

【0030】

第9面:

Am2=-7.4453E+00 , Am4=-7.0557E-08 , Am6=1.9461E-13
 Am8=-1.3606E-16 , Am10=-5.2312E-21 , Am12=-2.0517E-29
 Am14=-2.4196E-34
 B2=-1.1619E-08 , B4=-2.2670E-11 , B6=-1.5740E-15
 B8=-4.5789E-20 , B10=-3.8438E-24 , B12=-7.4648E-28
 B14=-5.8757E-32 , B16=1.1024E-36 , B18=1.5980E-40
 C0=-3.1492E-01
 I0=3.1657E-06 , I1=-1.3699E-09 , I2=1.2086E-10
 I3=4.1379E-12 , I4=3.0682E-13 , I5=-7.2697E-15
 I6=-1.1934E-16 , I7=4.3896E-18 , I8=1.3145E-20
 I9=-1.2026E-21 , I10=-2.1378E-24 , I11=1.7132E-25
 I12=7.8714E-28 , I13=-1.3127E-29 , I14=-1.2411E-31
 I15=5.1005E-34 , I16=8.2218E-36 , I17=-7.8048E-39
 I18=-1.9700E-40
 K0=3.3658E-08 , K1=5.7068E-11 , K2=-1.1867E-11
 K3=-1.6517E-13 , K4=-6.3184E-15 , K5=3.0942E-16
 K6=-1.4550E-18 , K7=-1.9660E-19 , K8=3.0045E-21
 K9=5.6936E-23 , K10=-9.5063E-25 , K11=-8.6717E-27
 K12=1.3624E-28 , K13=7.2210E-31 , K14=-1.0155E-32
 K15=-3.1157E-35 , K16=3.8226E-37 , K17=5.4542E-40
 K18=-5.7217E-42

【0031】

【発明の効果】以上説明したように、請求項1に係る光走査装置においては、補正光学系は、主走査方向、副走査方向共に負のパワーを持つアナモフィック面を有する樹脂製レンズと、少なくとも副走査方向に正のパワーを持つアナモフィック面を有するガラスレンズとを少なくとも1対有し、カップリング光学系と偏向反射面の間に設置されるので、環境温度の変動に伴う被走査面上の主走査方向の結像位置ずれ及び副走査方向の結像位置ずれを良好に補正すべく、上記補正用のレンズのアナモフィック面の曲率、線膨張係数、屈折率の温度依存性を最適に定めることにより、主走査及び副走査の両方向に対して、環境（温度、湿度）の変動に伴う焦点位置ずれを補正することができる。また、アナモフィック面を用いることにより、対向面は平面とすることができ、光学性能を劣化させる偏心の発生が抑えられる。

【0032】請求項2に係る光走査装置においては、上記請求項1の構成に加えて、アナモフィック面を有する樹脂製レンズとアナモフィック面を有するガラスレンズからなる補正光学系は保持部材で一体に保持することにより、補正光学系内で発生する波面収差を組み付け調整時に予め抑えることができる。請求項3に係る光走査装置においては、上記請求項2の構成に加えて、保持部材で一体化した補正光学系は、光軸方向に移動調整可能な構造を有することにより、補正光学系を光学系ユニット内に組付けるときに、主・副走査方向の焦点位置ずれを予め調整することができる。請求項4に係る光走査装置においては、上記請求項2の構成に加えて、保持部材で一体化した補正光学系は、光軸に垂直な方向に回転調整可能な構造を有することにより、補正光学系内の波面収差を保ちつつ、光学系全系の調整が可能となる。請求項5に係る光走査装置においては、上記請求項1、2、3または4の構成に加えて、補正光学系のアナモフィック面の少なくとも1面は、主・副走査方向共に非球面で構成されることにより、波面収差を良好に補正することが

できる。請求項6に係る光走査装置においては、上記請求項1、2、3、4または5の構成に加えて、アナモフィック面を有する樹脂製レンズとアナモフィック面を有するガラスレンズの面間隔を l とし、補正光学系全系の副走査方向の焦点距離を f_s としたとき、条件： $0 < l / f_s < 0.1$ を満足することにより、波面収差を良好に補正して小径の光スポットを得ることができる。

【図面の簡単な説明】

【図1】本発明の一実施形態を示す図であって、光走査装置を構成する光学系の配置を主走査平面に展開して示した光学配置説明図である。

【図2】図1に示す光走査装置の光源から偏向反射面に至る光路上の光学系配置の説明図であり、(a)は主走査方向の平面に展開した光路図、(b)は副走査方向の平面に展開した光路図である。

【図3】補正光学系のレンズを一体化した構成の一例を示す斜視図である。

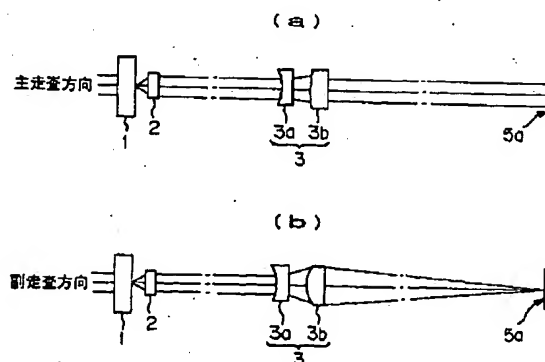
【図4】実施例に示す走査結像光学系を用いた場合の像面湾曲と等速特性を示す図である。

【図5】補正光学系のアナモフィック面に、トロイダル面を使用した時と、特殊トロイダル面を使用した時の波面収差を示す図である。

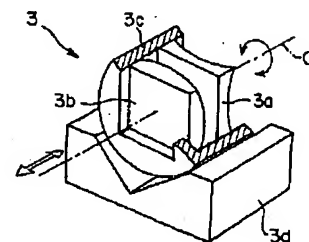
【符号の説明】

- 1：光源
- 2：カップリングレンズ
- 3：補正光学系
- 3a：樹脂製補正レンズ
- 3b：ガラス製補正レンズ
- 3c：補正光学系ユニット
- 3d：台座
- 4：平面鏡
- 5：光偏向器（ポリゴンミラー）
- 5a：偏向反射面
- 6：走査結像光学系
- 6a、6b：走査レンズ
- 7：被走査面

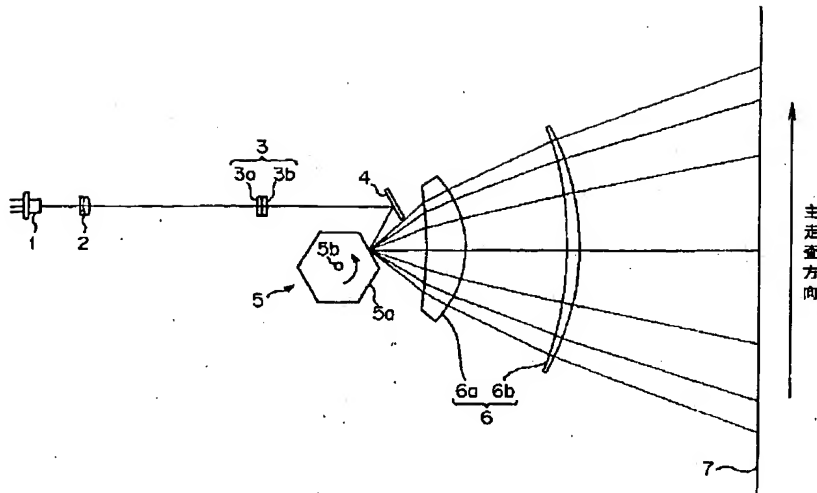
【図2】



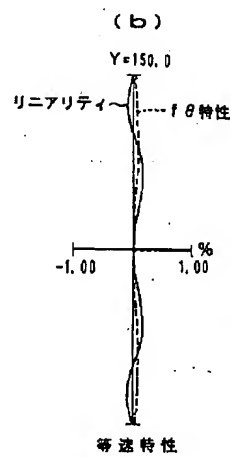
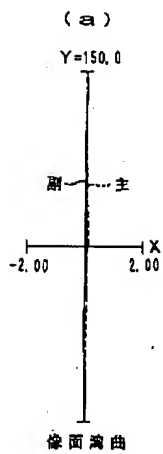
【図3】



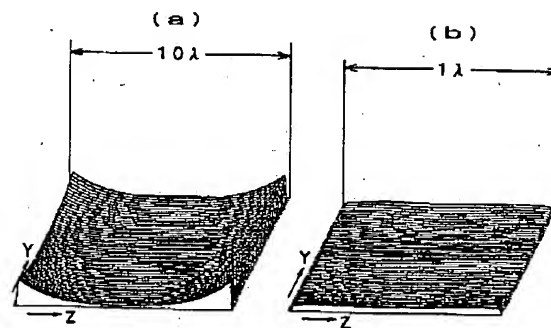
【図1】



【図4】



【図5】



フロントページの続き

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Fターム(参考) 2H045 AA01 CA34 CA44 CA54 CA67
CB04

PAT-NO: JP02001075032A

DOCUMENT-IDENTIFIER: JP 2001075032 A

TITLE: OPTICAL SCANNER

PUBN-DATE: March 23, 2001

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APPL-NO: JP11247540

APPL-DATE: September 1, 1999

INT-CL (IPC): G02B026/10

ABSTRACT:

PROBLEM TO BE SOLVED: To realize an optical scanner by which focusing position deviation in main and sub scanning directions caused in accordance with the change of ambient temperature can be self-corrected in the entire system of an optical system, and a light spot having a small diameter can be formed on a surface to be scanned regardless of temperature change.

SOLUTION: As to the optical scanner provided with a light source 1, the optical system 2 coupling a luminous flux from the light source to the successive optical system, an optical deflector 5 reflecting and deflecting the luminous flux from the coupling optical system by a deflecting and reflecting surface 5a, a scanning and image-forming optical system 6 condensing the deflected luminous flux by the optical deflector on a surface 7 to be scanned as the light spot, and a correction optical system 3 self-correcting the focusing position deviation of the light spot on the surface to be scanned caused in accordance with the ambient fluctuation; the system 3 has at least a pair of a resin lens 3a having an anamorphic surface having negative power both in the main scanning direction and in the sub-scanning direction and a glass lens 3b having the anamorphic surface having positive power at least in the sub-scanning direction, and is set between the system 2 and the surface 5a.

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PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2001-075032

(43)Date of publication of application : 23.03.2001

(51)Int.Cl.

G02B 26/10

(21)Application number : 11-247540

(71)Applicant : RICOH CO LTD

(22)Date of filing : 01.09.1999

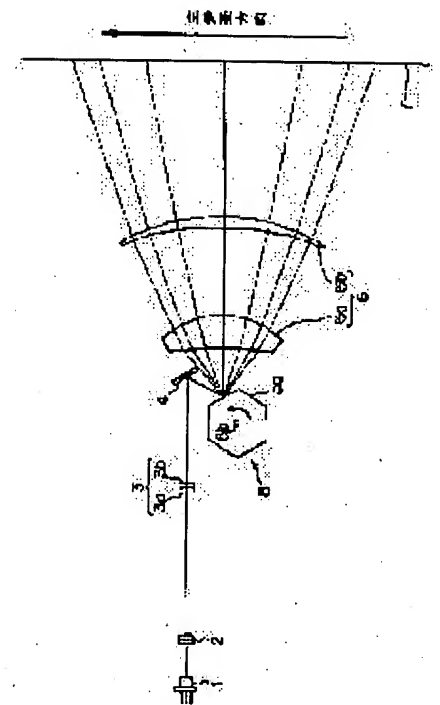
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(54) OPTICAL SCANNER

(57)Abstract:

PROBLEM TO BE SOLVED: To realize an optical scanner by which focusing position deviation in main and sub scanning directions caused in accordance with the change of ambient temperature can be self-corrected in the entire system of an optical system, and a light spot having a small diameter can be formed on a surface to be scanned regardless of temperature change.

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LEGAL STATUS

[Date of request for examination]

23.08.2002

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number]

3483129

[Date of registration]

17.10.2003

[Number of appeal against examiner's decision of rejection]

[Date of requesting appeal against examiner's decision of rejection]

[Date of extinction of right]

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CLAIMS

[Claim(s)]

[Claim 1] The light source which emits the flux of light, and the coupling optical system which carries out coupling to the optical system after changing the flux of light from this light source into the parallel flux of light, the abbreviation convergence flux of light, or the abbreviation divergence flux of light, The light deflector which reflects the flux of light from this coupling optical system in a deflection reflector, and carries out a deflection scan, In light-scanning equipment equipped with the scan image formation optical system which condenses the deflection flux of light by this light deflector as an optical spot on a scan layer-ed, and the amendment optical system for carrying out self-proving of the focal location gap of the optical spot on the above-mentioned scan layer-ed accompanying an environmental variation etc. The lens made of resin with which the above-mentioned amendment optical system has an anamorphic side with power negative in a main scanning direction and the direction of vertical scanning, Light-scanning equipment characterized by having at least one pair of glass lens which has the anamorphic side which has forward power in the direction of vertical scanning at least, and being installed between the above-mentioned coupling optical system and the above-mentioned deflection reflector.

[Claim 2] Light-scanning equipment characterized by holding to one the amendment optical system which consists of a lens made of resin which has an anamorphic side, and a glass lens which has an anamorphic side in light-scanning equipment according to claim 1 by the attachment component.

[Claim 3] Light-scanning equipment with which amendment optical system unified by the attachment component is characterized by having the structure in which migration adjustment in the direction of an optical axis is possible in light-scanning equipment according to claim 2.

[Claim 4] Light-scanning equipment with which amendment optical system unified by the attachment component is characterized by having the structure in which revolution adjustment in a direction vertical to an optical axis is possible in light-scanning equipment according to claim 2.

[Claim 5] Light-scanning equipment with which the 1st [at least] page of the anamorphic sides of amendment optical system is characterized by the Lord and the direction of vertical scanning consisting of the aspheric surfaces in light-scanning equipment according to claim 1, 2, 3, or 4.

[Claim 6] Light-scanning equipment characterized by satisfying condition: $0 < L/f_s < 0.1$ when the spacing of the lens made of resin which has an anamorphic side, and the glass lens which has an anamorphic side is set to L in light-scanning equipment according to claim 1, 2, 3, 4, or 5 and the focal distance of the direction of vertical scanning of the amendment optical-system whole system is set to f_s .

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the light-scanning equipment applied to the write-in optical system of image formation equipments, such as a laser beam printer, a digital copier, and facsimile, a measuring instrument, test equipment, etc.

[0002]

[Description of the Prior Art] The flux of light from the light source is deflected by the light deflector, it condenses as an optical spot on a scan layer-ed by scan optical system, and the light-scanning equipment which scans a scan-layer-ed top is widely known in relation to a laser beam printer, a digital copier, facsimile, etc. from the former. In such light-scanning equipment, it has the intention of the activity of the lens made of resin in order to realize the object which reduces lens cost, and a special lens side configuration. Although the special lens side configuration is variously proposed for the purpose of amendment with the lens (scan image formation lens) good [uniform properties, such as a curvature of field and linearity,] which constitutes the scan image formation optical system which carries out image formation of the deflection flux of light on a scan layer-ed especially, in order to realize such a special lens side configuration, the lens made of resin is suitable. On the other hand, there is a problem that the curvature and refractive index of a lens side change and the focal location of the optical spot on the lens engine performance, especially a scan layer-ed changes with the volume changes accompanying a temperature change in the lens made of resin, like common knowledge. Change of this focal location increases the diameter of a spot of the optical spot on a scan layer-ed, produces beam ****, and becomes the cause of reducing the resolution of light scanning.

[0003] Then, since it generates conversely mutually with a positive lens and a negative lens, in order that change of the focal location accompanying the temperature change of the lens made of resin may amend change of the above-mentioned focal location, arranging the scan image-formation lens made of resin and the lens made of resin with the power of reverse on the optical path from the light source to a light deflector, and offsetting change of the focal location by the temperature change of a scan image-formation lens is known (JP,8-160330,A, JP,8-292388,A). Light-scanning equipment given in JP,8-160330,A here It is a configuration containing the light source, an incident light study system, deflecting system, scan optical system, and a scanned medium. An incident light study system The first optical system which makes the divergence flux of light from the light source the parallel flux of light (collimate lens), It consists of the second optical system to which image formation of the light from the light source through this first optical system is carried out near the deflecting system in the direction of vertical scanning, and is considering as the configuration containing the optical element made of resin (lens) which has negative power in the direction of vertical scanning at either the first optical system or the second optical system. Moreover, in the 1st image formation section which carries out image formation near the deflection location of deflecting system, scan optical equipment given in JP,8-292388,A has negative refractive power only in the direction of vertical scanning, is equipped with a negative lens made from resin, and is considering it as the configuration which performs temperature compensation.

[0004]

[Problem(s) to be Solved by the Invention] However, with the light-scanning equipment indicated by the above-mentioned conventional technique, since the lens made of resin for amendment arranged between the light source and a light deflector is a lens which has negative power only in the direction of vertical scanning and did not have power about the main scanning direction, the focal location gap (gap of the image formation location of an optical spot) of the main scanning direction accompanying the temperature change of a scan image formation lens was not able to be amended. Moreover, since the lens for amendment in the conventional technique constituted the lens cross section from a usual radii configuration, it had the problem of having degraded wave aberration on the contrary and becoming the hindrance of minor-diameter-izing of an optical spot with the lens for amendment.

[0005] this invention be make in view of the above-mentioned situation, also when the lens made of resin be use for the optical system which carry out image formation of the deflection flux of light on a scan layer-ed, carry out self-proving of the focal location gap of the main scanning direction accompanying change of environmental temperature and the direction of vertical scanning in the whole system of optical system, and let it be a technical problem to realize the light scanning equipment which can form the optical spot of a minor diameter on a scan layer-ed irrespective of a temperature change.

[0006]

[Means for Solving the Problem] As above-mentioned The means for solving a technical problem, the light-scanning equipment concerning this invention The light source which emits the flux of light, and the coupling optical system which carries out coupling to the optical system after changing the flux of light from this light source into the parallel flux of light, the abbreviation convergence flux of light, or the abbreviation divergence flux of light, The light deflector which reflects the flux of light from this coupling optical system in a deflection reflector, and carries out a deflection scan, It has the scan image formation optical system which condenses the deflection flux of light by this light deflector as an optical spot on a scan layer-ed, and the amendment optical system for carrying out self-proving of the focal location gap of the optical spot on the above-mentioned scan layer-ed accompanying an environmental variation etc. And the above-mentioned amendment optical system has the lens made of resin which has the anamorphic side in which a main scanning direction and the direction of vertical scanning have negative power, and at least one pair of glass lens which has the anamorphic side which has forward power in the direction of vertical scanning at least, and is installed between the above-mentioned coupling optical system and the above-mentioned deflection reflector (claim 1).

[0007] In the light-scanning equipment concerning above-mentioned claim 1, it is desirable to hold to one the amendment optical system which consists of a lens made of resin which has an anamorphic side, and a glass lens which has an anamorphic side by the attachment component (claim 2). And in the light-scanning equipment concerning above-mentioned claim 2, it is desirable that the amendment optical system unified by the attachment component has the structure in which migration adjustment in the direction of an optical axis is possible (claim 3). Or in the light-scanning equipment concerning above-mentioned claim 2, it is desirable that the amendment optical system unified by the attachment component has the structure in which revolution adjustment in a direction vertical to an optical axis is possible (claim 4). Furthermore, in the light-scanning equipment concerning above-mentioned claims 1, 2, 3, or 4, as for the 1st [at least] page of the anamorphic sides of amendment optical system, it is desirable that the Lord and the direction of vertical scanning consist of the aspheric surfaces (claim 5). Moreover, in the light-scanning equipment concerning above-mentioned claims 1, 2, 3, 4, or 5, when the spacing of the lens made of resin which has an anamorphic side, and the glass lens which has an anamorphic side is set to L and the focal distance of the direction of vertical scanning of the amendment optical-system whole system is set to fs, it is desirable to satisfy condition: $0 < L/fs < 0.1$ (claim 6).

[0008]

[Embodiment of the Invention] Hereafter, the configuration of this invention, actuation, and an operation are explained to a detail with reference to a drawing. Drawing 1 is drawing showing 1 operation gestalt of this invention, and is the optical arrangement explanatory view having developed and shown arrangement of the optical system which constitutes light-scanning equipment at the horizontal-scanning flat surface (flat surface parallel to an optical axis and a main scanning direction). The coupling optical system 2 which carries out coupling to the optical system after the optical system shown in drawing 1 changes into the parallel flux of light, the abbreviation convergence flux of light, or the abbreviation divergence flux of light the flux of light from the light source 1 which emits the flux of light, and this light source 1, The light deflector 5 which reflects the flux of light from the coupling optical system 2 by deflection reflector 5a, and carries out a deflection scan. It has the scan image formation optical system 6 which condenses the deflection flux of light by the light deflector 5 as an optical spot on the scan layer 7-ed, and the amendment optical system 3 for carrying out self-proving of the focal location gap of the optical spot on the above-mentioned scan layer-ed accompanying an environmental variation etc. And the amendment optical system 3 has correcting lens 3made of resin a which has the anamorphic side in which a main scanning direction and the direction of vertical scanning have negative power, and at least one pair of glass correcting lens 3b which has the anamorphic side which has forward power in the direction of vertical scanning at least, and is installed between the above-mentioned coupling optical system 2 and the above-mentioned deflection reflector 5a (claim 1). In addition, a sign 4 is a plane mirror for optical-path bending, and is installed if needed.

[0009] Here, although semiconductor laser is used as the light source 1, light emitting diode (LED) etc. can also be used. The coupling optical system 2 is a coupling lens which consists of an unit or two or more lenses, and it carries out coupling so that the optical system (amendment optical system) after changing into the parallel flux of light, the abbreviation convergence flux of light, or the abbreviation divergence flux of light the divergence flux of light emitted from the light source 1 may be made to suit. Although a glass lens or the lens made of resin is sufficient as this coupling lens 2, it is desirable to constitute from a glass lens which cannot be easily influenced by environmental variations, such as temperature. Moreover, in order to remove spherical aberration, it is good also considering a lens side as an aspheric surface configuration. the amendment optical system 3 -- the both directions of horizontal scanning and vertical scanning -- receiving -- an environmental variation (temperature --) Although the focal location gap accompanying humidity is amended (it mentions later for details) Usually, as it has a function as line image formation optical system and is shown in optical-path drawing developed at the flat surface of optical-path drawing developed at the flat surface of the (a) main scanning direction of drawing 2, and the direction of (b) vertical scanning The flux of light from the coupling lens 2 is converged in the direction of vertical scanning (direction which intersects perpendicularly with space in drawing 1), and image formation is carried out to a main scanning direction as a long line image near the deflection reflector 5a of a light deflector 5. By making revolving-shaft 5b of a motor into a medial axis, a light deflector 5 is a rotating polygon (polygon mirror) which carries out a uniform revolution, and deflects the reflected light bundle by deflection reflector 5a in constant angular velocity by the uniform revolution of the polygon mirror 5. In addition, as a light deflector, a revolution unifacial mirror, the 2nd page mirror of a revolution, etc. can be suitably used other than a polygon mirror. The scan image formation optical system 6 is constituted according to an operation of the scan lenses 6a and 6b on the scan layer 7 (with image formation equipments, such as a laser beam printer and a digital copier, the sensitization side of the photo conductor of a photoconductivity etc. turns into a scan layer-ed)-ed. In addition, the scan image formation optical system 6 can be constituted not only from the combination of two lenses but from one lens, or can also consist of three or more lenses. Moreover, it can also constitute from combination with one or more lenses, a concave mirror with an image formation operation, ftheta mirror, etc. Furthermore, when it constitutes the scan image formation optical system 6 from two scan lenses 6a and 6b like drawing 1, the lens made of resin of an aspheric surface configuration is used for one [at least] scan lens for a lens side for amendment of the curvature of field of the Lord and the direction of vertical scanning, and an improvement of a uniform property (linearity, ftheta property).

[0010] Next, the amendment optical system 3 which is the description of this invention is explained. Correcting lens 3a made of resin which has the anamorphic side in which both the amendment optical system 3 has negative power in a main scanning direction and the direction of vertical scanning as shown in drawing 1 and 2, It consists of glass correcting lens 3b which has the anamorphic side (a cylinder side is included) which has forward power in the direction of vertical scanning at least. The temperature dependence of the curvature of this anamorphic side, coefficient of linear expansion, and a refractive index is defined the optimal that an image formation location gap of the main scanning direction on the scan layer 7-ed in accordance with fluctuation of environmental temperature and an image formation location gap of the direction of vertical scanning should be amended good.

[0011] Here, the following effectiveness is acquired by making the correcting lenses 3a and 3b of the amendment optical system 3 into an anamorphic side.
** The focal location gap accompanying environmental (temperature, humidity) fluctuation can be amended to the both directions of horizontal scanning and vertical scanning.

** Since an opposed face can be made into a flat surface by using an anamorphic side, this can be made into the datum clamp face and generating of the eccentricity which degrades optical-character ability is suppressed.

** An anamorphic side can be processed now comparatively easily by a cut in recent years and development of a polish processing technique. Therefore, it can realize, without combining a cylinder side, the spherical surface, etc. like the former.

[0012] Moreover, this invention does not carry out self-proving of the focal location gap of the scan image formation optical system 6 (scan lenses 6a and 6b) accompanying environmental (temperature, humidity) fluctuation by the amendment optical system 3 before deflection reflector 5a of the polygon mirror 5, and the curvature of field itself is not amended fundamentally. Therefore, as for the curvature of field (deflection of the focal gap within 1 scan) of the scan image formation optical system 6, amending good beforehand is desirable. So, in the example mentioned later, as an anamorphic side (for example, a toroidal side and a special toroidal side), as shown in drawing 4, optical-character ability, such as a curvature of field and a uniform property (linearity, ftheta property), is improved for the field configuration of the scan lenses 6a and 6b which constitute the scan image formation optical system 6. In addition, the above-mentioned special toroidal side is a toroidal side where the curvature in a vertical-scanning cross section (imagination cross section which intersects perpendicularly with a main scanning direction) changes in a main scanning direction.

[0013] Next, in drawing 1 and the light-scanning equipment of a configuration of being shown in 2, as for the amendment optical system 3 which consists of correcting lens 3made of resin a which has an anamorphic side, and glass correcting lens 3b which has an anamorphic side, holding to one by the attachment component is desirable, for example, as shown in drawing 3, it is constituted so that correcting lens 3made of resin a of the amendment optical system 3 and glass correcting lens 3b may be held to one by amendment optical-system unit 3c. Moreover, by constituting the appearance of amendment optical-system unit 3c in the shape of a cylinder, and installing in 3d of plinths which have the slot of a V character configuration, along the above-mentioned slot, migration accommodation can be carried out or it can consider as a pivotable configuration in the direction vertical to the direction of an optical axis in the direction of an optical axis O.

[0014] Here, there are the following merits by constituting in one the correcting lenses 3a and 3b which constitute the amendment optical system 3 from unit 3c, as shown in drawing 3.

** When two or more anamorphic sides exist (it is the 4th page to the 2nd page and scan optical system in amendment optical system at the example mentioned later), the revolution eccentricity within the field which intersects perpendicularly with an optical axis generates big wave aberration, and generates **** of an optical spot. Then, by holding correcting lens 3made of resin a of the amendment optical system 3, and glass correcting lens 3b to one by optical-system unit 3c, the wave aberration generated within the amendment optical system 3 can be attached, and it can stop beforehand at the time of adjustment (claim 2).

** When attaching the amendment optical system 3 in optical-system unit 3c by considering unified amendment optical system as the configuration in which

migration adjustment in the direction of an optical axis is possible like drawing 3, a focal location gap of the Lord and the direction of vertical scanning can be adjusted beforehand (claim 3).

** Adjustment of the optical-system whole system is attained, maintaining the wave aberration within amendment optical system by making unified amendment optical system a configuration pivotable in a direction vertical to the direction of an optical axis like drawing 3 (claim 4).

[0015] By the way, the densification of writing progresses in image formation equipments, such as a laser beam printer and a digital copier, and the high density writing exceeding 1200dpi (dots per inch) has been implementation-ized in recent years. In order to correspond to such densification, it is necessary to minor-diameter-ize the diameter of a spot of the optical spot on a scan layer-ed, and for that purpose, a raise in NA of optical system is required. Since the flux of light which penetrates optical system by high NA-ization becomes large, the wave aberration generated in that case affects the diameter of an optical spot greatly, and when wave aberration is too large, it cannot narrow down to the optical spot of a minor diameter. So, as for the 1st [at least] page of the anamorphic sides of two correcting lenses which constitute the amendment optical system 3, the Lord and the direction of vertical scanning are made to consist of this inventions in the aspheric surface. More specifically, the correcting lenses 3a and 3b which constitute the amendment optical system 3 become possible [amending wave aberration good] by making it have the 1st [at least] page of the special toroidal side which has non-radii in a main scanning direction or the direction of vertical scanning (claim 5). Although the concrete example of amendment optical system is mentioned later, in an example, wave aberration is amended good by making the anamorphic side of the concave by the side of the optical incidence of lens 3made of resin a of amendment optical system (coupling lens side) into a special toroidal side. In addition, the wave aberration the case where the toroidal side of (a) usual radii is used for the anamorphic side of the concave by the side of the optical incidence of correcting lens 3made of resin a of the amendment optical system 3, and at the time of using a (b) special toroidal side is shown, and, as for drawing 5, by considering as a special toroidal side shows that wave aberration is amended good.

[0016] Here, the expression for specifying the lens side configuration of the special toroidal side applied to the correcting lenses 3a and 3b of the above-mentioned amendment optical system 3 and the scan lenses 6a and 6b of the scan image formation optical system 6 is explained. However, this invention is not limited to this expression. In expressing a lens side, the coordinate of Y and the direction of vertical scanning is set to Z for the coordinate of a main scanning direction [/ near the lens side], and these zeros are taken to an optical axis. The general formula of a lens side is set to $f(Y, Z) = f_m(Y) + f_s(Y, Z)$. The field configuration in the horizontal-scanning cross section (a lens optical axis is included and it is an imagination cross section parallel to a main scanning direction) of a special toroidal side is making the non-radii configuration here, $f_m(Y)$ of the 1st term of the right-hand side of the above-mentioned formula expresses the configuration in a horizontal-scanning cross section, and $f_s(Y, Z)$ of the 2nd term expresses the configuration in the vertical-scanning cross section (imagination cross section which intersects perpendicularly with a main scanning direction) in the location of coordinate: Y in a main scanning direction.

[0017] Below, when making distance of the main scanning direction from Rm and an optical axis to Y and making [the formula of a well-known non-radii configuration, i.e., the paraxial radius of curvature in the horizontal-scanning cross section in an optical axis,] Km and a high order multiplier into Am1, Am2, Am3, Am4, Am5, and .. for a cone constant by setting the configuration in the above-mentioned horizontal-scanning cross section to $f_m(Y)$, the following polynomial expresses by setting the depth of the direction of an optical axis to X.

$X = f(Y, Z) = f_m(Y) + f_s(Y, Z)$ (1) $f_m(Y) = (Y^2/R_m) / [1 + \sqrt{1 - (1 + K_m)(Y/R_m)^2}] + Am_1 + Y + Am_2 + Y^2 + Am_3 + Y^3 + Am_4 + Y^4 + Am_5 + \dots$ When it is not 0 by (2) and (2) formula the oddth any of multiplier: Am1, Am3 and Am5, and .. they are, a non-radii configuration turns into an unsymmetrical configuration in a main scanning direction. Moreover, the even multiplier: Only in Am2, Am4, Am6, and .., it becomes the symmetry in a main scanning direction. In addition, in the above-mentioned notation, " Y^2 " expresses " Y^2 " and " Y^3 " expresses " Y^3 ." Moreover, Above $f_s(Y, Z)$ is expressed as follows. $f_s(Y, Z) = (Z^2 \text{ and } Cs) / [1 + \sqrt{1 - (1 + K_s)(Z - Cs)^2}] + F_0 + F_1 + Y + F_2 + Y^2 + F_3 + Y^3 + F_4 + Y^4 + \dots - Z + G_0 + G_1 + Y + G_2 + Y^2 + G_3 + Y^3 + G_4 + Y^4 + \dots - Z^2 + H_0 + H_1 + Y + H_2 + Y^2 + H_3 + Y^3 + H_4 + Y^4 + \dots - Z^3 + I_0 + I_1 + Y + I_2 + Y^2 + I_3 + Y^3 + I_4 + Y^4 + \dots - Z^4 + J_0 + J_1 + Y + J_2 + Y^2 + J_3 + Y^3 + J_4 + Y^4 + \dots - Z^5 + K_0 + K_1 + Y + K_2 + Y^2 + K_3 + Y^3 + K_4 + Y^4 + \dots - Z^6 + \dots$ (3) Here $Cs = (1/R_{s0}) + B_1 + Y + B_2 + Y^2 + B_3 + Y^3 + B_4 + Y^4 + B_5 + \dots$ (4) $K_s = K_{s0} + C_1 + Y + C_2 + Y^2 + C_3 + Y^3 + C_4 + Y^4 + C_5 + \dots$ It is (5), and " R_{s0} " is the paraxial radius of curvature in a vertical-scanning cross section including an optical axis. Moreover, the oddth coefficient B 1 of Y, B3, B5 .. When it is except zero any they are, the curvature in a vertical-scanning cross section becomes unsymmetrical to a main scanning direction. Similarly, when it is except zero any of the oddth multiplier of multiplier: C1, C3 and C5, .., F1, F3, F5, .., G1, G3, G5, .., etc. and Y showing the amount of non-radii they are, the amount of non-radii of vertical scanning becomes unsymmetrical to a main scanning direction. In the below-mentioned example, the plane-of-incidence side of correcting lens (lens made of resin) 3a by the side of the light source of the amendment optical system 3 is made into the special toroidal side written by the above-mentioned formula, and four lens sides of two scan lenses 6a and 6b of the scan image formation optical system 6 are made into the special toroidal side written by the above-mentioned formula.

[0018] Next, in this invention, when the spacing of glass lens 3b which has lens 3made of resin a which has an anamorphic side, and an anamorphic side is set to L in the light-scanning equipment of a configuration of being shown in drawing 1 -3 and the focal distance of the direction of vertical scanning of the amendment optical-system 3 whole system is set to fs, it is characterized by satisfying following condition: $0.005 < L/fs < 0.1$ (claim 6). Here, if 0.1 of the upper limit of the above-mentioned conditions is exceeded, in order to amend the focal gap by the environmental variation, since the distance between deflection reflector 5a of a light deflector 5 and the amendment optical system 3 becomes long too much, constraint of a layout is received. On the other hand, since the negative power of lens 3made of resin a will become large too much if 0.005 of a minimum is exceeded, degradation of wave aberration is caused and it becomes difficult to obtain the optical spot of a minor diameter on the scan layer 7-ed. In addition, in the optical system shown in the below-mentioned example, it is $L/fs = 1.0 / 131 = 0.0076$.

[0019] Now, in this invention **** light-scanning equipment of a configuration of having explained above, the result of having compared the amount of image surface fluctuation (image formation location gap) and the image surface range of fluctuation of the Lord and the direction of vertical scanning the case (temperature cancellation method) where the amendment optical system 3 performs temperature compensation, and when not performing temperature compensation (with no temperature cancellation) is shown in the following table 1.

[0020]

[A table 1]

表 1. 温度補正効果

方式		T/h	像面変動量 [mm]							像面 変動幅
			h=150	h=122.7	h=78.7	h=0	h=-78.7	h=-122.7	h=-150	
温度キャンセル 無し	主走査	10℃	-1.04	-1.01	-1.07	-1.03	-1.07	-1.01	-1.02	2.37
		45℃	1.15	1.12	1.18	1.24	1.18	1.12	1.13	
	副走査	10℃	-1.24	-1.21	-1.28	-1.24	-1.27	-1.30	-1.27	2.79
		45℃	1.36	1.43	1.46	1.42	1.45	1.46	1.35	
温度キャンセル 方式	主走査	10℃	-0.22	-0.18	-0.14	-0.14	-0.14	-0.16	-0.22	0.48
		45℃	0.24	0.16	0.14	0.13	0.14	0.16	0.23	
	副走査	10℃	-0.18	-0.23	-0.18	-0.11	-0.17	-0.23	-0.18	0.56
		45℃	0.23	0.35	0.28	0.21	0.28	0.32	0.23	

h : 像高、T : 温度

[0021]

[Example] The concrete example of the optical system in the light-scanning equipment of a configuration of having been shown below drawing 1 -3 is shown. In this example, the light source 1 is semiconductor laser and is luminescence wavelength:655nm. The coupling lens 2 is a glass lens (FD10) of the single ball configuration held at the cel member made from aluminum, a focal distance is $f=22.0\text{mm}$ and outgoing radiation light is the parallel flux of light. In addition, in this example, make a field number 1 and outgoing radiation side side into the field number 2 for the plane-of-incidence side of correcting lens 3 made of resin a of the amendment optical system 3 by making the lens side by the side of the outgoing radiation of the coupling lens 2 into the field number 0, and let a field number 3 and outgoing radiation side side be the field number 4 for the plane-of-incidence side of glass correcting lens 3b. Moreover, the field number of deflection reflector 5a is set to 5, and two scan lenses 6a and 6b which constitute the scan image formation optical system 6 set a field number to 6, 7, 8, and 9 from a plane-of-incidence side at order.

[0022] Deflection reflector 5a of the polygon mirror which constitutes a light deflector 5 is a flat surface, and is condensing [natural] point:infinity. This polygon mirror The number of deflection reflectors: It is the 6th page and an inradius:25mm thing, and they are revolution medial-axis 5b and a reflective spot (the chief ray of the deflection flux of light). The intersection location of the above-mentioned beam of light and deflection reflector when becoming the optical axis of the scan lenses 6a and 6b and parallel was left distance:10.7mm in the above-mentioned optical-axis direction, and it is separated from it distance:22.69mm to the main scanning direction. Moreover, in the condition that the chief ray of the deflection flux of light becomes the optical axis of the scan lenses 6a and 6b, and parallel, the include angle (namely, incident angle to a polygon mirror) which this chief ray and the chief ray of the flux of light which carries out incidence to a deflection reflector from a light source side accomplish is 60 degrees. Moreover, a field angle is -38 - +38 degrees.

[0023] the amendment optical system 3 -- focal distance: -- correcting lens 3a made of resin is refractive-index: $n=1.52716$, by the field number, it is $f=131\text{mm}$ and the 2nd page is [the 1st page is a special toroidal side of a concave configuration, and] a flat surface. Moreover, glass correcting lens 3b is refractive-index: $n=1.514332$ (BK7), by the field number, the 3rd page is a toroidal side of a convex configuration, and the 4th page is a flat surface. Scan lens 6a by the side of the polygon mirror 5 of the scan image formation optical system 6 is refractive-index: $n=1.52716$ in the product made of resin, and its 6th page is the special toroidal side of a concave configuration, and a special toroidal side of a convex configuration with the unsymmetrical page [7th] curvature of a vertical-scanning cross section by the field number. Moreover, scan lens 6b by the side of the scan layer 7-ed is refractive-index: $n=1.52716$ in the product made of resin, and the special toroidal side of a concave configuration where the curvature of a vertical-scanning cross section is [the 8th page] unsymmetrical, and the 9th page are [the Lord and a vertical-scanning cross section] special toroidal sides of the convex configuration of non-radii by the field number. Paraxial radius of curvature which is the above-mentioned here: The lens data of optical system to R_m , R_{s0} , and spacing: x on an optical axis are shown below.

[0024]

A field number R_m R_{s0} x Correcting lens 3a 1 - 100.9 - 17.76 3.0 2 infinity infinity 1.0 Correcting lens 3b 3 100.0 15.0 3.0 4 infinity infinity 140.64 Deflection reflector 5a S infinity infinity The 72.560 scan lens six a6 - 242.186 242.337 31.572 7-83.064 138.908 81.808 scan lens 6b 8 -239.054 -78.986 9.854 9 -218.790 -26.516 145.001 [0025] moreover -- the above -- resin -- make -- a correcting lens -- three -- a -- the -- one -- a page -- and -- a scan -- a lens -- six -- a -- six -- b -- the -- six -- a page -- the -- nine -- a page -- special -- toroidal one -- a field -- a lens -- a field -- a configuration -- specifying -- a sake -- the above-mentioned -- a formula -- (-- one --) - (-- five --) -- it can set -- each -- a multiplier -- a value -- the following -- being shown . In addition, in each multiplier data shown below, it means that E attached to the numerical tail and the numeric value following it hang BEKI ** of 10, for example, "E-15" means "x10-15."

[0026] the 1st page : A_{m1} , A_{m2} , A_{m3} , A_{m4} , A_{m5} , and .. =0 B-2=-2.9712E-05 B4=-8.5101E-07 B6=4.1938E-09 C0=1.8861E+00 C1=4.5792E-02 C3=-5.6507E-04 I0=-3.0182E-05 I1=-9.6650E-07 I3=1.2955E-08 K0=-1.4683E-06 K1=4.9604E-08 K3=1.2755E-08 [0027]

The 6th page : $A_{m2}=6.9335E-01$ $A_{m4}=-3.7002E-09$ $A_{m6}=5.3962E-12$ $A_{m8}=-2.6877E-14$ $A_{m10}=3.2892E-18$ B-2=-1.0850E-05 B4=4.4623E-09 B6=-1.4980E-12 B8=-1.1955E-15 B10=1.4318E-18 B12=-3.5225E-22 B14=-2.8072E-25 B16=1.3039E-28 [0028]

The 7th page : $A_{m2}=-2.3702E-01$ $A_{m4}=5.2751E-08$ $A_{m6}=-2.0673E-13$ $A_{m8}=6.1916E-16$ $A_{m10}=-2.1272E-18$ B1=1.1285E-05 B3=8.2414E-09 B5=-8.3701E-12 B7=1.6093E-15 B9=1.0336E-19 [0029]

The 8th page : $A_{m2}=-9.0813E+00$ $A_{m4}=-1.3697E-10$ $A_{m6}=-1.0361E-12$ $A_{m8}=-1.5020E-16$ $A_{m10}=-1.2669E-21$, $A_{m12}=-4.0301E-25$ $A_{m14}=5.7340E-30$ $A_{m16}=1.6885E-33$ B1=1.5474E-06 B3=2.8010E-10 B5=-1.2492E-13 B7=2.5220E-17 B9=-3.6112E-21 B11=2.9135E-25 B13=-1.6452E-29 B15=1.7857E-33 B17=-1.0747E-37 [0030]

The 9th page : $A_{m2}=-7.4453E+00$ $A_{m4}=7.0557E-08$ $A_{m6}=1.9461E-13$ $A_{m8}=-1.3606E-16$ $A_{m10}=-5.2312E-21$ $A_{m12}=-2.0517E-29$ $A_{m14}=-2.4196E-34$ B-2=-1.1619E-08 B4=-2.2670E-11 B6=-1.5740E-15 B8=-4.5789E-20 B10=-3.8438E-24 B12=-7.4648E-28 B14=-5.8757E-32 B16=1.1024E-36 B18=1.5980E-40 C0=-3.1492E-01 I0=3.1657E-06 I1=-1.3699E-09 I2=1.2086E-10 I3=4.1379E-12 I4=3.0682E-13 I5=-7.2697E-15 I6=-1.1934E-16 I7=4.3896E-18 I8=1.3145E-20 I9=-1.2026E-21 I10=-2.1378E-24 I11=1.7132E-25 I12=7.8714E-28 I13=-1.3127E-29 I14=-1.2411E-31 I15=5.1005E-34 I16=8.2218E-36 I17=-7.8048E-39 I18=-1.9700E-40 K0=3.3658E-08 K1=5.7068E-11 K2=-1.1867E-11 K3=-1.6517E-13 K4=-6.3184E-15 K5=3.0942E-16 K6=-1.4550E-18 K7=-1.9660E-19 K8=3.0045E-21 K9=5.6936E-23 K10=-9.5063E-25 K11=-8.6717E-27 K12=1.3624E-28 K13=7.2210E-31 K14=-1.0155E-32 K15=-3.1157E-35 K16=3.8226E-37 K17=5.4542E-40 K18=-5.7217E-42 [0031]

[Effect of the Invention] In the light-scanning equipment applied to claim 1 as explained above The lens made of resin with which amendment optical system has an anamorphic side with power negative in a main scanning direction and the direction of vertical scanning, Since it has at least one pair of glass lens which has the anamorphic side which has forward power in the direction of vertical scanning at least and is installed between coupling optical system and a

deflection reflector That an image formation location gap of the main scanning direction on the scan layer-ed in accordance with fluctuation of environmental temperature and an image formation location gap of the direction of vertical scanning should be amended good The focal location gap accompanying environmental (temperature, humidity) fluctuation can be amended to the both directions of horizontal scanning and vertical scanning by defining the temperature dependence of the curvature of the anamorphic side of the lens for the above-mentioned amendment, coefficient of linear expansion, and a refractive index the optimal. Moreover, since an opposed face can be made into a flat surface by using an anamorphic side, this can be made into the datum clamp face and generating of the eccentricity which degrades optical-character ability is suppressed.

[0032] In addition to the configuration of above-mentioned claim 1, by holding to one by the attachment component, the amendment optical system which consists of a lens made of resin which has an anamorphic side, and a glass lens which has an anamorphic side can attach the wave aberration generated within amendment optical system, and can stop it beforehand in the light-scanning equipment concerning claim 2 at the time of adjustment. In the light-scanning equipment concerning claim 3, the amendment optical system which was unified by the attachment component in addition to the configuration of above-mentioned claim 2 can adjust beforehand a focal location gap of the Lord and the direction of vertical scanning, when attaching amendment optical system in an optical-system unit by having the structure in which migration adjustment in the direction of an optical axis is possible. In the light-scanning equipment concerning claim 4, the adjustment of the optical-system whole system of it is attained, the amendment optical system which was unified by the attachment component in addition to the configuration of above-mentioned claim 2 maintaining the wave aberration within amendment optical system by having the structure in which revolution adjustment in a direction vertical to an optical axis is possible. In addition to the configuration of above-mentioned claims 1, 2, 3, or 4, in the light-scanning equipment concerning claim 5, the 1st [at least] page of the anamorphic sides of amendment optical system can amend wave aberration good by the Lord and the direction of vertical scanning consisting of the aspheric surfaces. In the light-scanning equipment concerning claim 6, when the spacing of the lens made of resin which has an anamorphic side, and the glass lens which has an anamorphic side is set to L in addition to the configuration of above-mentioned claims 1, 2, 3, 4, or 5 and the focal distance of the direction of vertical scanning of the amendment optical-system whole system is set to fs, by satisfying condition: $0 < L/fs < 0.1$, wave aberration can be amended good and the optical spot of a minor diameter can be obtained.

[Translation done.]

* NOTICES *

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1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. **** shows the word which can not be translated.
3. In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is drawing showing 1 operation gestalt of this invention, and is the optical arrangement explanatory view having developed and shown arrangement of the optical system which constitutes light-scanning equipment at the horizontal-scanning flat surface.

[Drawing 2] It is the explanatory view of the optical-system arrangement on the optical path from the light source of the light-scanning equipment shown in drawing 1 to a deflection reflector, and optical-path drawing which developed (a) at the flat surface of a main scanning direction, and (b) are optical-path drawings developed at the flat surface of the direction of vertical scanning.

[Drawing 3] It is the perspective view showing an example of a configuration of having unified the lens of amendment optical system.

[Drawing 4] It is drawing showing the curvature of field and uniform property at the time of using the scan image formation optical system shown in an example.

[Drawing 5] It is drawing showing the time of using a toroidal side for the anamorphic side of amendment optical system, and the wave aberration when using a special toroidal side.

[Description of Notations]

- 1: Light source
- 2: Coupling lens
- 3: Amendment optical system
- 3a: The correcting lens made of resin
- 3b: Glass correcting lens
- 3c: Amendment optical-system unit
- 3d: Plinth
- 4: Plane mirror
- 5: Light deflector (polygon mirror)
- 5a: Deflection reflector
- 6: Scan image formation optical system
- 6a, 6b: Scan lens
- 7: A scan layer-ed

[Translation done.]